Northeast Gulf Science

Volume 12
Number 1 *Number 1*

Article 4

11-1991

Life History and Ecology of Sand Seatrout *Cynoscion arenarius* Ginsburg, in the Northern Gulf of Mexico: A Review

James G. Ditty
Louisiana State University

Marty Bourgeois
Louisiana Department of Wildlife and Fisheries

Rick Kasprzak
Louisiana Department of Wildlife and Fisheries

Mark Konikoff
University of Southwestern Louisiana

DOI: 10.18785/negs.1201.04

Northeast Gulf Science Vol. 12, No. 1 November 1991 p. 35-47

LIFE HISTORY AND ECOLOGY OF SAND SEATROUT *Cynoscion arenarius* GINSBURG, IN THE NORTHERN GULF OF MEXICO: A REVIEW

James G. Ditty
Coastal Fisheries Institute
Center for Wetland Resources
Louisiana State University
Baton Rouge, LA 70803-7503
and
Marty Bourgeois
Louisiana Department of Wildlife and Fisheries
P. O. Box 189
Bourg, LA 70343
and
Rick Kasprzak
Louisiana Department of Wildlife and Fisheries
P. O. Box 98000
Baton Rouge, LA 70898-9000
and
Mark Konikoff
Department of Biology
University of Southwestern Louisiana
P. O. Box 42451
Lafayette, LA 70504

ABSTRACT: Sand seatrout usually represent from 5-7% of trawl catches by weight, 8-10% by number, and consistently rank among the top 5 most abundant species in demersal surveys. Sand seatrout mature at 140-180 mm TL, begin to enter the late developing, gravid, or ripe stages around 180 mm TL, and first spawn at 12 months. Spawning occurs primarily from March through September with distinct peaks in both March-April and August-September. Spawning initially takes place in midshelf to offshore waters and moves shoreward as the season progresses, with most occuring in the lower estuary and shallow GOMEX (7-15 m water depth). Larvae are primarily collected in water depths of <25 m, more are collected at night than during the day, and they are somewhat surface-oriented but become increasingly demersal with size. In pass studies, larval sand seatrout are also more abundant on night flood tides than at other times. Larvae migrate into shallow areas of the estuary where they remain until at least 50-60 mm TL after which they move to deeper water. Mean size predicted by regression was 250, 425, and 573 mm TL at ages I, II, and III, with a typical lifespan of 1-2 years and possibly up to 3 years. Total annual mortality approaches 100% based on trawl data if the lifespan is one year and 90% if two years. Distribution of sand seatrout appears restricted more by water temperature than salinity. Electrophoretic evidence is unclear whether sand seatrout should be recognized as distinct from weakfish. Evidence provided by otolith aging of larvae and differences in larval pigmentation, however, supports the separation of two co-occurring morphological types and suggests separate populations of sand seatrout in the northern Gulf of Mexico.

Sand seatrout, *C. arenarius*, are harvested both commercially and recreationally in the Gulf of Mexico (GOMEX) and are one of the most important finfish in commercial fisheries of the northern Gulf, contributing a major portion of the industrial bottomfish and foodfish fleet catches (Gutherz *et al.*, 1975). Sand seatrout usually represent from 5-7% of trawl catches by weight (*e.g.*, Moore *et al.*, 1970; Dunham, 1972; Franks *et al.*, 1972; Chittenden and McEachran, 1976; Warren, 1981), 8–10% by number (*e.g.*, Gunter 1936, 1938a, 1945; Perret and Caillouet, 1974; Warren, 1981) and consistently rank among the top five most abundant species in demersal surveys. The fishery is centered around the Mississippi River Delta, an area of high bottomfish densities (Sheridan *et al.*, 1984). Landings of industrial bottomfish from the northern GOMEX have increased dramatically since 1953 (Gutherz *et al.*, 1975) and by 1975 sand seatrout ranked 12th in total landings and 14th in ex-vessel values in GOMEX commercial fisheries (Nakamura, 1981). Sand seatrout are also a major segment of the finfish discards of the shrimp fleet (Gunter, 1936; Gutherz *et al.*, 1975; Juhl and Drummond, 1977), ranking second by weight off Mississippi and Louisiana (Pavella, 1977), and third by number of individuals collected/yr (Butch Pellegrin, *pers. comm.*)[1]. Sand seatrout account for over 5% of finfish bycatch in the northcentral gulf and in the northwestern gulf (Juhl and Drummond, 1977), but contribute <1% to the bycatch of the northeastern GOMEX. Although this species remains common in the northern GOMEX, sand seatrout utilization will continue to increase with fishing pressure resulting from more stringent management of the more popular and exploited species. Despite its abundance, many aspects of sand seatrout life history have been relatively poorly studied, information is widely scattered and some is conflicting. There has been one previous synopsis of sand seatrout data but this review (Sutter and McIlwain, 1987) does not discuss stock identification problems, early life history information, or attempt to resolve discrepancies in other aspects of seatrout life history. Therefore, the objectives of this paper are to review and synthesize sand seatrout life history data, provide some new information on seasonal movements, resolve discrepancies where possible and identify areas requiring further study.

STOCK DESCRIPTION

The taxonomic status of sand seatrout as a species distinct from weakfish, *C. regalis*, is still uncertain. Sand seatrout are primarily restricted to the GOMEX (Florida Bay to Campeche Bay) and weakfish to the Atlantic coast of the U.S. and Canada (Nova Scotia to southern Florida), but two adult weakfish have been captured in the GOMEX off southern Florida near Marcos Island (Weinstein and Yerger, 1976). Sand seatrout and weakfish have been recognized as distinct species or at least sub-species based on morphometric and meristic counts but there is considerable overlap in characters (Ginsburg, 1929). Differences in larval pigmentation, age, and growth data (Ditty, 1984; Cowan, 1985; Cowan *et al.*, 1989; Ditty, 1989) indicate that two larval types of sand seatrout occur in the northern GOMEX. Temporal separation of two distinct spawned groups each year also suggest separate populations or species but similarities in the life history and population dynamics of sand seatrout and weakfish suggest that they may be conspecific (Shlossman and Chittenden, 1981). Electrophoretic evidence is unclear whether sand seatrout and weakfish are reproductively isolated (Paschall, 1986) and whereas one study suggests that sand seatrout should be recognized as a sub-species of weakfish (Weinstein and Yerger, 1976) another study found that separation of these two taxa was uncertain (Paschall, 1986). While literature on the possibly conspecific weakfish might apply to sand seatrout, we herein follow Robins *et al.* (1980) and refer to

[1]Butch Pellegrin, National Marine Fisheries Service, Southeast Fisheries Center, Pascagoula, MS.

sand seatrout as a species separate from weakfish and therefore do not include literature on weakfish (see Wilk, 1979; Mercer, 1983 for review).

REPRODUCTION AND EARLY LIFE HISTORY

Sand seatrout mature at 140-180 mm total length (TL), begin to enter the late developing, gravid, or ripe stages around 180 mm TL, and first spawn at 12 months (Shlossman and Chittenden, 1981). Similar sizes at maturation have been reported in another study (Sheridan *et al.*, 1984) with the smallest maturing male and female of 129 and 140 mm SL. Maturing and ripe sand seatrout are mainly collected during March and April (*e.g.*, Moffett *et al.*, 1979; Shlossman and Chittenden, 1981; Sheridan *et al.*, 1984), although maturing females have also been collected during August (Sheridan *et al.*, 1984). Male to female sex ratios vary by study and show no pattern (Table 1).

Fecundities of sand seatrout (N = 131) from the Mississippi Delta region increase with standard length (SL) and range from 28,200 eggs for a 210 mm SL (142.8 gm) female to 324,900 eggs for a 224 mm SL (223.7 gm) female (Sheridan *et al.*, 1984). Fecundity (F), defined as the potential number of eggs spawned over a reproductive season assuming all counted eggs would be released, was related to fish length (SL), weight (W), and ovary weight (OW) as follows:

$$F = -198{,}665 + 1{,}480\,SL \quad r^2 = 0.36$$
$$F = -8{,}917 + 759\,W \quad r^2 = 0.51$$
$$F = 32{,}557 + 7{,}893\,OW \quad r^2 = 0.53$$

Sand seatrout are less fecund than similar size weakfish, with sand seatrout (140-268 mm SL) averaging 100,900 eggs and weakfish (190-268 mm SL) 285,700 eggs (Sheridan *et al.*, 1984).

Sand seatrout larvae have been collected from January (Cowan, 1985) through October in the northern GOMEX above 26°00′ N lat. (Ditty *et al.*, 1988) and year-round off southwest Florida (Peebles, 1987), but spawning occurs primarily from March through September with distinct peaks during both March–April and August–September (*e.g.*, Jannke, 1971; Shlossman and Chittenden, 1981; Sheridan *et al.*, 1984; Ditty, 1986). Little spawning occurs during mid-summer and none between October and December based on gonad maturity data (Shlossman and Chittenden, 1981; Sheridan *et al.*, 1984). Spawning in the laboratory occurs soon after (usually 1–2 hrs) lab-simulated dusk (Holt *et al.*, 1985). Egg diameters range from 0.67–0.90 mm and hatching usually occurs between 18–36 hrs. after spawning depending on water temperature (Holt *et al.*, 1988).

Off Texas, most maturing and ripe female sand seatrout (38%) were collected between the 56 and 73 m isobaths (Sheridan *et al.*, 1984), whereas they occurred at depths of 73–91 m off Mississippi (Franks *et al.*, 1972). This variation in depth, however, may be due to differences in habitat depths off Texas and the Mississippi Delta (Sheridan *et al.*, 1984). The presence of larvae (<3.0 mm TL) in midshelf to offshore waters (15–80 m water depth) early in the season suggests that spawning initially takes place at these depths (Cowan and Shaw, 1988). Spawning moves shoreward as the season progresses (Cowan and Shaw, 1988) with most occurring in the lower estuary and shallow GOMEX. The main "nursery" is in water <18 m deep (Shlossman and Chittenden, 1981). Spawning location is probably determined by salinity and intensity of spawning by water temperature (Peebles, 1987).

Larval sand seatrout are primarily collected in water depths of <25 m (Ditty *et al.*, 1988), more are collected at night than during the day, and they are somewhat surface-oriented (Peebles, 1987;

Table 1. Male:Female sex ratios of sand seatrout, *Cynoscion arenarius*, from the northern Gulf of Mexico.

AUTHORS	SEX RATIO	N	STUDY LOCATION
Landry and Armstrong 1980	1:1.32	849	Western Louisiana
Moffett *et al.* 1979	1:1.66	498	Galveston Bay, TX
Sheridan *et al.* 1984	1.09:1	1191	Pensacola Bay, FL to Brownsville, TX
Shlossman and Chittenden 1981	1.30:1	1776	Upper Texas Coast

Cowan and Shaw, 1988; Leffler, 1989; Lyczkowski-Shultz *et al.*, 1990) but become increasingly demersal with size (Rogers and Herke, 1985; Peebles, 1987). In pass studies, larval sand seatrout are also more abundant on night flood tides than at other times (Simmons and Hoese, 1959; Lyczkowski-Shultz *et al.*, 1990). Larvae migrate into shallow areas of the upper estuaries (Benson, 1982) and apparently prefer small bayous, shallow marshes, and channels during their early life stages (Conner and Truesdale, 1972; Moffett *et al.*, 1979) moving to deeper areas as they grow. Two-layered circulation has been hypothesized as the mechanism of transport toward and retention in nursery areas of Naples Bay, Florida, and would allow the smaller larvae in the lower part of the bay to remain in relatively high salinity waters while maintaining proximity to low salinity habitats utilized by the more euryhaline postlarvae and juveniles (Peebles, 1987). Off Louisiana, however, across-shelf transport of larvae was an order of magnitude smaller than along-shore western advective transport and this may account for the lack of a clear offshore/onshore larval size gradient (Cowan and Shaw, 1988). Shelf spawning is toward the east or "upstream" of larval landfall and there is a 1-2 month delay between offshore spawning and the first appearance of marsh migrants (Shaw *et al.*, 1988). Sand seatrout <30 mm SL first appear in estuaries during April and continue to immigrate throughout the summer and early fall (*e.g.*, Perret *et al.*, 1971; Franks *et al.*, 1972; Warren and Sutter, 1982b) but with distinct peaks during April-May and September-October.

AGE, GROWTH, AND MORTALITY

Off Louisiana, late winter-early spring spawned sand seatrout larvae (2.2-11.1 mm TL) ranged from 10 to 70 days old (Cowan *et al.*, 1989). In addition, larval age and growth data (Cowan, 1985; Cowan *et al.*, 1989) support the separation based on pigmentation (Ditty, 1984; Ditty, 1989) of two co-occurring morphological types. These age and growth data found that morph A grew significantly faster (6 mm TL/mon) than morph B (4.2 mm TL/mon) at water temperatures of 20-21 °C (Cowan, 1985) and suggest separate populations in the northern GOMEX. Off Naples Bay, Florida, larval growth was estimated at 0.31 mm SL/day (9.3 mm SL/mon) for water temperatures of 25 °C or higher and for fish between 1.7-5.5 mm SL (Peebles, 1987).

Length-frequency data indicate that growth was faster for spring spawned (16.0-27.7 mm SL/mon) than late summer spawned (10.2-14.7 mm SL/mon) sand seatrout off Mississippi, with an estimated mean growth rate of 23.2 mm SL/mon for spring spawned seatrout (Warren *et al.*, 1978; Warren, 1981). Growth was also greater for spring spawned (35 mm TL/mon) than late summer spawned (5-10 mm TL/mon) sand seatrout off Texas (Shlossman and Chittenden, 1981).

Lengths at age based on length-frequency data averaged 210–280 mm TL depending on spawned group with mean sizes predicted by regression of 250, 425, and 573 mm TL at ages I, II, and III (Shlossman and Chittenden, 1981). Length at age based on scales was consistent with estimates from length-frequency data but scale age determination was probably impossible for fish older than II or III (Shlossman and Chittenden, 1981). Mean back-calculated TL and age of sand seatrout (N = 48) from the northcentral GOMEX based on otoliths ($Y = 178.8 + 87.1X$; $r = 0.68$) was 200 mm TL at age I and 247 mm TL at age II (Barger and Johnson, 1980). Protracted spawning, continued recruitment, and possible gear selectivity problems, however, complicate age and growth determination, hence estimation of juvenile growth from length-frequency data are possible only over short periods (weeks) but questionable over months (Warren and Sutter, 1982b; Shlossman and Chittenden, 1981).

Few sand seatrout exceed a maximum size of 300 mm TL (Chittenden and McEachran, 1976; Shlossman and Chittenden, 1981), although published records have reported several trawl-caught fish up to about 500 mm TL (Franks *et al.*, 1972; Adkins and Bowman, 1976). Maximum lifespan of sand seatrout is typically 1–2 yrs and possibly up to 3 yrs (Chittenden and McEachran, 1976; Shlossman and Chittenden, 1981). Comparison of length-weight relationships of sand seatrout from throughout the GOMEX (Table 2) suggest that there might be distinct populations off Texas (Vetter, 1977; Moffett *et al.*, 1979; Shlossman and Chittenden, 1981) and the Louisiana-Mississippi coast (Dawson, 1965; Warren, 1981; Warren and Sutter, 1982a). Weight per unit length increases more rapidly for sand seatrout off Texas than for those off Louisiana/Mississippi but the differences in slope between these two areas could result from gear selectivity biases or from the lack of juvenile sand seatrout in the three aforementioned Texas studies.

A larval instantaneous mortality coefficient has been estimated at 0.31 (*i.e.*, 27%/day) for larvae <5 mm SL, with a total larval mortality of 99% by 5 mm SL. For postlarvae (>5 mm SL), the annual mortality would result in a loss of over 97% of the stock (Peebles, 1987). Adult sand seatrout off Texas have a total annual mortality rate that approaches 100% and a best estimate of 99.8% based on trawl data if lifespan is one year and a total annual mortality of about 90% if two years (Shlossman and Chittenden, 1981). Continued recruitment during late spring and early summer, however, probably biases sand seatrout mortality estimates (Warren, 1981). High mortality rates also result from heavy fishing pressure exerted by trawlers for several weeks after the opening of shrimp season because brown shrimp (*Penaeus aztecus*) and juvenile sand seatrout simultaneously occupy similar estuarine and nearshore areas (Gunter, 1936; Warren, 1981).

HABITAT, MOVEMENT, AND ECOLOGY

Sand seatrout inhabit shelf and estuarine waters of the GOMEX from southwest Florida to the Gulf of Campeche (Ditty *et al.*, 1988 for review). Of the three species of *Cynoscion* found in the GOMEX, the annual migratory pattern of sand seatrout (*i.e.*, moving offshore during the fall and winter and returning to the bays and estuaries during the spring and summer) is most similar to that of the typical white shrimp grounds community of demersal fishes (Chittenden and McEachran, 1976). In contrast, silver seatrout usually remain offshore and spotted seatrout in estuaries and bays throughout the year (Simmons, 1957; Swingle, 1971). Larvae and early juvenile sand seatrout (<30 mm SL) usually begin

Table 2. Summary of the length-weight relationship for sand seatrout, *Cynoscion arenarius*, from the Gulf of Mexico. Weight is measured in grams and length in mm standard length (SL), except where noted. All logs are base 10.

AUTHOR	STUDY LOCATION	N	SIZE RANGE	LENGTH-WEIGHT
Warren 1981	Mississippi Sound	—	16–217	log W = −4.6575 + 2.9572 log SL
Warren and Sutter 1982a	Mississippi Sound	1155[1]	12–180	log W = −4.5408 + 2.8919 log SL
		956	13–180	= −4.6524 + 2.9603 log SL
		1378	12–180	= −4.4245 + 2.8298 log SL
		1008	12–177	= −4.4729 + 2.8589 log SL
		1797	13–180	= −4.5909 + 2.9185 log SL
		2362	11–178	= −4.6498 + 2.9512 log SL
		2071	13–180	= −4.7119 + 2.9793 log SL
		779	14–180	= −4.6241 + 2.9314 log SL
Dawson 1965	Louisiana-Mississippi	507	40–205	log W = −4.5115 + 2.8922 log SL
Sheridan *et al.* 1984	Pensacola Bay, FL to Brownsville, TX	1191	82–310	log W = −4.46 + 2.86 log SL
Matlock and Strawn 1976	Galveston Bay, TX	289	14–119	log W = −4.5797 + 2.9206 log SL
Moffett *et al.* 1979	Galveston Bay, TX	144♀[2]	125–375	log W = −*5.0943* + 3.1130 log SL
		123♂	135–350	= −5.1226 + 3.1313 log SL
				TL = 0.7 + 1.1 SL
Shlossman and Chittenden 1981	Upper Texas Coast	653♀	—	log W = −5.6325 + 3.2420 log TL
		851♂	—	log W = −5.6609 + 3.2572 log TL
		1775[3]	40–338	= −5.4698 + 3.1715 log TL
				SL = −6.49 + 0.85 TL
Vetter 1977	Aransas Bay, TX	52	140–330	log W = −5.16 + 3.1494 log SL

[1] Years 1974 through 1981
[2] Regression equations between males and females were significantly different at $\alpha = 0.05$
[3] Male, female, and immature combined

to immigrate to estuaries during April, peaking in May (*e.g.*, Copeland and Bechtel, 1974) and emigrate from bays and estuaries to GOMEX waters at the onset of cool weather during fall and winter (Gunter, 1945; Guest and Gunter, 1958; Benefield, 1970; Tarbox, 1974). Immature fish are collected throughout the "nursery" area during the summer and early fall (Gunter, 1938b; Perret *et al.*, 1971; Swingle, 1971; Christmas and Waller, 1973), but are most abundant in GOMEX estuaries where they remain until at least 50–60 mm TL (Chittenden and McEachran, 1976). Off Louisiana[2], there is a rapid decline in both minimum and mean TL of sand seatrout collected at offshore stations (30 m station depth) during May and June, coincident with a rapid increase in both minimum and mean TL of fish collected at nearshore stations (10 m station depth) during June and July. During early fall, both minimum and mean TL of sand seatrout in nearshore waters decrease as larger fish move further offshore and immature fish move out of the estuary into deeper waters. These same trends are evident when comparing CPUE and mean TL of sand seatrout collected nearshore with those offshore.

Distribution of sand seatrout appears restricted more by water temperature than salinity (Trent *et al.*, 1969). Juveniles and adults have been collected at water temperatures from 5–37 °C (Table 3), with highest catches between 20–35 °C and drastically reduced catches at tem-

[2]Unpublished data provided by the Louisiana Department of Wildlife and Fisheries, Coastal Investigations Section and the Louisiana Offshore Oil Port (LOOP, Inc.) Project.

peratures <6 °C and >35 °C (Copeland and Bechtel, 1974). Sand seatrout larvae (<20 mm SL) and early juveniles (20–90 mm SL) in Mississippi Sound were more abundant at water temperatures between 20–30 °C (no catch at <15 °C) and those between 90 and 220 mm SL were most frequently collected at water temperatures of 25–30 °C (Warren and Sutter, 1982b). Sand seatrout migrate in and out of the estuary to avoid water temperature extremes because of an inability to undergo metabolic rate compensation (Vetter, 1982). There is reportedly no optimum salinity or relationship between catch ratio and salinity (Copeland and Bechtel, 1974). In addition, sand seatrout distribution within the estuary does not appear related to salinity (Trent *et al.*, 1969), although larvae and juveniles are more tolerant of low salinities than adults (Gunter, 1945; Benson, 1982). A study of Mississippi Sound, however, found catches of sand seatrout (90–220 mm SL) higher at salinities >15 ppt, juveniles (20–90 mm SL) at <15 ppt, and newly recruited larvae and early juveniles (<20 mm SL) at 0–30 ppt than at other salinities (Warren and Sutter, 1982b).

Food habits of sand seatrout have been relatively well-studied (*e.g.*, Reid, 1955; Reid *et al.*, 1956; Darnell, 1958; Dietz, 1976; Moffett *et al.*, 1979; Sheridan, 1979; Byers, 1981; Creel and Divita, 1982; Divita *et al.*, 1983; Sheridan and Trimm, 1983; Kasprzak and Guillory, 1984; Sheridan *et al.*, 1984) and show that seatrout are opportunistic carnivores whose diet changes with growth (Moffett *et al.*, 1979; Sheridan, 1979; Byers, 1981; Kasprzak and Guillory, 1984). Age, habitat, abundance of suitable prey and its availability in different geographic locations influence their diet (Byers, 1981; Sheridan and Trimm, 1983). Young sand seatrout (<40 mm SL; Byers, 1981) primarily consume plankton-size organisms (*i.e.*, copepods, mysids) but gradually became piscivorous as adults. A shift in feeding behavior also occurs around 160 mm SL with smaller seatrout preferring crustaceans and those larger preferring fish (Moffett *et al.*, 1979; Kasprzak and Guillory, 1984). Engraulids dominated the

Table 3. Water temperature (°C) and salinity (ppt) range data for juvenile and adult sand seatrout, *Cynoscion arenarius*.

AUTHOR	TEMPERATURE	SALINITY	SIZE (mm)	LOCATION
Roessler 1970	19.5–26.0	16.4–35.7	-	Everglades Natl. Park, FL
Reid 1954	10.0–27.1	17.5–24.8	39–84	Cedar Key, FL
Gunter and Hall 1965	-	0–23.0	31–209	Caloosahatchee Estuary, FL
Springer and Woodburn 1960	21.1–31.5	3.7–29.8	29–141	Tampa Bay, FL
Sykes and Finucane 1966	-	0.1–37.2	14–258	Tampa Bay, FL
Tagatz and Wilkens 1973	21.7–31.7	2.6–23.0	30–305	Pensacola Bay, FL
Swingle 1971	-	0.2–30.0	19–260	Alabama Estuaries
Swingle and Bland 1974	13.7–30.6	0.4–28.1	14–174	Coastal Alabama
Franks *et al.* 1972	10.8–29.5	16.6–39.8	71–453	Mississippi Sound
Christmas 1973	5.0–34.9	.0–35.5	16–304	Mississippi Sound
Warren and Sutter 1982 b	15.0–30.0+	.0–30.0	<20	Mississippi Sound
El-Sayed 1961	8.3–34.5	1.0–25.4	35–228	Lake Borgne-Breton Sound, LA
Fox and Mock 1968	22.0–31.0	20.0–30.0	-	Barataria Bay, LA
Dunham 1972	12.3–35.2	1.0–32.6	20–345	Barataria Bay, LA
Perret and Caillouet 1974	11.0–34.0	0–25.0	31–308	Vermilion Bay, LA
Perret *et al.* 1971	5.0–34.9	0.2–30.0+	15–295	Louisiana coastwide
Galloway and Strawn 1974	5.0–40.0	-	10–149	Galveston Bay, TX
Gunter 1945	13.7–36.7	0–37.2	18–377	Port Aransas, TX area
Miller 1965	12.8–27.8	27.3–36.0	35–236	Off Port Aransas, TX

diet in some studies (*e.g.*, Moffett *et al.*, 1979; Sheridan, 1979; Byers, 1981) and menhaden in other studies and there is some intraspecific cannibalism (Reid, 1955; Reid *et al.*, 1956; Darnell, 1958). There is also a shift in food habits during the fall and winter with sand seatrout consuming relatively more crustaceans than during other months (Sheridan, 1979; Byers, 1981). In addition, piscivorous prey is more abundant in the diet of sand seatrout inshore than those offshore (Byers, 1981).

Areas requiring further study include population age structure and growth rates, stock(s) identification and geographic distribution, mortality, and fecundity. In conclusion, these data represent the current knowledge of sand seatrout life history and ecology in the GOMEX. Hopefully, this information will provide a foundation upon which further research and sound management of the fishery can be based.

ACKNOWLEDGMENTS

We would like to thank the Coastal Investigations Section of the Louisiana Department of Wildlife and Fisheries, the Louisiana Offshore Oil Port (LOOP, Inc.), and the National Marine Fisheries Service (Pascagoula Lab) for providing unpublished trawl data. Thanks also to Jim Hanifen and the LSU Department of Experimental Statistics for additional support. Jim Cowan and an anonymous reviewer provided helpful suggestions to improve the manuscript. Louisiana State University Contribution No. LSU-CFI-91-4.

LITERATURE CITED

Adkins, G., and P. Bowman. 1976. A study of the fauna in dredged canals of coastal Louisiana. La. Wildl. Fish. Comm., Tech. Bull. No. 18, 72 p.

Barger, L.E., and A.G. Johnson. 1980. An evaluation of marks on hardparts for age determination of Atlantic croaker, spot, sand seatrout, and silver seatrout. NOAA Tech. Mem., NMFS-SEFC-22, 15 p.

Benefield, R.L. 1970. A study of sand seatrout *Cynoscion arenarius* Ginsburg of the Galveston Bay area. Texas Parks Wildl. Dept., Coastal Fish. Branch Proj. Rep. 1970: 217–225.

Benson, N.G., (*ed.*). 1982. Life history requirements of selected finfish and shellfish in Mississippi Sound and adjacent areas. U.S. Fish and Wildl. Serv., Office Biol. Serv., Washington, D.C. FWS/OBS-81/51, 97 p.

Byers, S.M. 1981. Trophic relationships of two sympatric sciaenid fishes, *Cynoscion arenarius* and *Cynoscion nothus*, in the northcentral Gulf of Mexico. Master's Thesis, Univ. Southern Miss., Hattiesburg, 70 p.

Chittenden, M.E., Jr., and J.D. McEachran. 1976. Composition, ecology, and demersal fish communities on the northwestern Gulf of Mexico continental shelf, with a similar synopsis for the entire Gulf. Texas A & M Univ., College Station, TAMU-SG-76-208.

Christmas, J.Y., (*ed.*). 1973. Cooperative Gulf of Mexico estuarine inventory and study, Mississippi. Gulf Coast Res. Lab., Ocean Springs, MS., No. 9, 502 pp.

Christmas, J.Y., and R.H. Waller. 1973. Estuarine vertebrates, Mississippi. Pp. 323–406, *In:* J.Y. Christmas (*ed.*), Cooperative Gulf of Mexico estuarine inventory and study, Mississippi. Gulf Coast Res. Lab., Ocean Springs, MS, No. 9, 502 pp.

Conner, J.V., and F.M. Truesdale. 1972. Ecological implications of a freshwater impoundment in a low salinity marsh, p. 259–276. *In:* R.H. Chabreck (*ed.*), Proceedings of the coastal marsh and estuary management symposium. Louisiana St. Univ., Baton Rouge.

Copeland, B.J., and T.J. Bechtel. 1974.

Some environmental limits of six Gulf coast estuarine organisms. Contrib. Mar. Sci., Univ. Texas 18: 169-204.

Cowan, J.H., Jr. 1985. The distribution, transport and age structure of drums (Family Sciaenidae) spawned in the winter and early spring in the continental shelf waters off west Louisiana. Ph.D. Thesis, Louisiana St. Univ., Baton Rouge, 182 p.

Cowan, J.H., Jr., and R.F. Shaw. 1988. The distribution, abundance and transport of larval sciaenids collected during winter and early spring from the continental shelf waters off west Louisiana. Fish. Bull. (U.S.) 86(1): 129-142.

Cowan, J.H., Jr., R.F. Shaw, and J.G. Ditty. 1989. Occurrence, age and growth of two morphological types of sand seatrout (*Cynoscion arenarius*) larvae in the winter and early spring coastal waters off west Louisiana. Contrib. Mar. Sci., Univ. Texas 31: 39-50.

Creel, M., and R.C. Divita. 1982. The occurrence of *Penaeus* spp. in the stomachs of trawl-caught fishes from the northwestern Gulf of Mexico. U.S. Dept. Commer., NOAA Tech. Mem., NMFS-SEFC-87.

Darnell, R.M. 1958. Food habits of fishes and larger invertebrates of Lake Ponchartrain, Louisiana, an estuarine community. Publ. Inst. Mar. Sci., Univ. Texas 5: 353-416.

Dawson, C.E. 1965. Length-weight relationships of some Gulf of Mexico fishes. Trans. Am. Fish. Soc. 94(3): 279-280.

Dietz, R.A. 1976. Food and feeding habits of *Cynoscion arenarius* Ginsburg, *Cynoscion nebulosus* (Cuvier), and *Bairdiella chrysura* (Lacepede) (Pisces: Sciaenidae) in the Anclote Anchorage, Tarpon Springs, Florida. Master's Thesis, Univ. South Florida, St. Petersburg, 83 pp.

Ditty, J.G. 1984. Seasonality of sciaenids in the northern Gulf of Mexico. Assoc. Southeastern Biol. 31(2): 55.

Ditty, J.G. 1986. Ichthyoplankton in neritic waters of the northern Gulf of Mexico off Louisiana: composition, relative abundance, and seasonality. Fish. Bull. (U.S.) 84(4): 935-946.

Ditty, J.G. 1989. Separating early larvae of sciaenids from the western North Atlantic: A review and comparison of larvae off Louisiana and Atlantic coast of the U.S. Bull. Mar. Sci. 44(3): 1083-1105.

Ditty, J.G., G.G. Zieske, and R.F. Shaw. 1988. Seasonality and depth distribution of larval fishes in the northern Gulf of Mexico above latitude 26°00′ N. Fish. Bull. (U.S.) 86(4): 811-823.

Divita, R.C., M. Creel, and P.F. Sheridan. 1983. Foods of coastal fishes during brown shrimp, *Penaus aztecus*, migration from Texas estuaries (June-July 1981). Fish. Bull. (U.S.) 81(2): 396-402.

Dunham, F. 1972. A study of commercially important estuarine dependent industrial fishes. Louisiana Wildl. Fish. Comm., Tech. Bull. No. 4, 63 p.

El-Sayed, S.Z. 1961. Hydrological and biological studies of the Mississippi River-Gulf Outlet Project. U.S. Fish Wildl. Serv., Texas A & M Project 286, Ref. 61-20F, College Station, Texas, 215 pp.

Fox, L.S., and W. Mock, Jr. 1968. Seasonal occurrence of fishes in two shore habitats in Barataria Bay, Louisiana. Proc. La. Acad. Sci. 31: 43-53.

Franks, J.S., J.Y. Christmas, W.L. Siler, R. Combs, R. Waller, and C. Burns. 1972. A study of nektonic and benthic faunas of the shallow Gulf of Mexico off the State of Mississippi as related to some physical, chemical, and geological factors. Gulf Res. Rep. 4(1): 1-148.

Galloway, B.J., and K. Strawn. 1974. Seasonal abundance and distribution of marine fishes at a hot-water discharge in Galveston Bay, Texas. Contrib. Mar. Sci., Univ. Texas 18: 72-137.

Ginsburg, I. 1929. Review of the weakfishes (*Cynoscion*) of the Atlantic and Gulf coasts of the United States, with a description of a new species. Bull. Bur. Fish. 65: 71-85.

Guest, W.C., and G. Gunter. 1958. The seatrout or weakfishes (genus *Cynoscion*) of the Gulf of Mexico. Gulf States Mar. Fish. Comm. Tech. Summary, No. 1, 40 pp.

Gunter, G. 1936. Studies on the destruction of marine fish by shrimp trawlers in Louisiana. La. Conserv. Rev. 5(4): 18-24 and 45-46.

Gunter, G. 1938a. The relative numbers of species of marine fish on the Louisiana coast. Amer. Nat. 72: 77-83.

Gunter, G. 1938b. Seasonal variations in abundance of certain estuarine and marine fishes in Louisiana, with particular reference to life histories. Ecol. Monogr. 8: 313-346.

Gunter, G. 1945. Studies on marine fishes of Texas. Publ. Inst. Mar. Sci., Univ. Texas 1(1): 1-190.

Gunter, G., and G.E. Hall. 1965. A biological investigation of the Caloosahatchee Estuary of Florida. Gulf Coast Res. Lab., Ocean Springs, MS., 71 pp.

Gutherz, E.J., G.M. Russell, A.F. Serra, and B.A. Rohr. 1975. Synopsis of the northern Gulf of Mexico industrial and foodfish industries. Mar. Fish. Rev. 37(7): 1-11.

Holt, G.J., S.A. Holt, and C.R. Arnold. 1985. Diel periodicity of spawning sciaenids. Mar. Ecol. Prog. Ser. 27: 1-7.

Holt, S.A., G.J. Holt, and L. Young-Abel. 1988. A procedure for identifying sciaenid eggs. Contrib. Mar. Sci., Univ. Texas 30 (Supplement): 99-107.

Jannke, T.E. 1971. Abundance of young sciaenid fishes in Everglades National Park, Florida, in relation to season and other variables. Sea Grant Tech. Bull. No. 11, Univ. Miami, FL, 128 p.

Juhl, R., and S.B. Drummond. 1977. Shrimp bycatch investigation in the United States of America: A status report. Pp. 213-226, *In:* H.B. Stewart, Jr. (*ed.*), Cooperative investigations of the Caribbean and adjacent regions-II. FAO Fish. Rep. No. 200.

Kasprzak, R.A., and V. Guillory. 1984. Food habits of sand seatrout in Barataria Bay, Louisiana. Proc. Annu. Conf. Southeast Assoc. Fish Wildl. Agencies 38: 480-487.

Landry, A.M., and H.W. Armstrong. 1980. Determine seasonal abundance, distribution and community composition of demersal finfishes and macrocrustaceans. *In:* W.B. Jackson and G.W. Faws, (*eds.*), Biological/Chemical survey of Texoma and Capline sector salt dome brine disposal sites off Louisiana, 1978-1979, Vol. IV. NOAA Tech. Mem., NMFS-SEFC-28, 180 p.

Leffler, D.L. 1989. Composition, abundance, and small-scale distribution of ichthyoplankton off the Louisiana-Mississippi barrier islands, with special emphasis on the age, growth, and mortality of *Chloroscombrus chrysurus*. Master's Thesis, Louisiana St. Univ., Baton Rouge, 150 p.

Lyczkowski-Shultz, J., D.L. Ruple, S.A. Richardson, and J.H. Cowan, Jr. 1990. Distribution of fish larvae relative to time and tide in a Gulf of Mexico barrier island pass. Bull. Mar. Sci. 46(3): 563-577.

Matlock, G., and K. Strawn. 1976. Standard length-weight relationship of 22 fishes from the upper Galveston Bay, Texas. Texas Agric. Exper. Stn. Misc. Publ. MP-1286, 4 p.

Mercer, L.P. 1983. A biological and fisheries profile of weakfish, *Cynoscion regalis*. N. Car. Dept. Nat. Resourc. Comm. Dev., Spec. Sci. Rep. No. 39, 107 pp.

Miller, J.M. 1965. A trawl survey of the shallow Gulf fishes near Port Aransas, Texas. Publ. Inst. Mar. Sci., Univ. Texas 10: 80-107.

Moffett, A.W., L.W. McEachron, and J.G.

Keys. 1979. Observations on the biology of sand seatrout (*Cynoscion arenarius*) in Galveston and Trinity Bays, Texas. Contrib. Mar. Sci., Univ. Texas 22: 163–172.

Moore, D., H.A. Brusher, and L. Trent. 1970. Relative abundance, seasonal distribution, and species composition of demersal fishes off Louisiana and Texas, 1962–1964. Contrib. Mar. Sci., Univ. Texas 15: 45–70.

Nakamura, E.L. 1981. Sciaenid resources in the Gulf of Mexico, p. 29–39. *In:* H. Clepper (*ed.*), Marine recreational fisheries. Vol. 6, Proc. 6th Ann. Recr. Fish. Symp., Houston, Texas.

Paschall, R.L., Jr. 1986. Biochemical systematics of the seatrouts of the western Atlantic, genus *Cynoscion*. Master's Thesis, Univ. New Orleans, Louisiana, 99 p.

Pavella, J.S. 1977. An analysis of the finfish discards resulting from commercial shrimp trawling in the northcentral Gulf of Mexico. Master's Thesis, Univ. Southern Miss., Hattiesburg, 143 p.

Peebles, E.B. 1987. Early life history of the sand seatrout, *Cynoscion arenarius*, in southwest Florida. Master's Thesis, Univ. South Florida, St. Petersburg, 70 p.

Perret, W.S., and C.W. Caillouet, Jr. 1974. Abundance and size of fishes taken by trawling in Vermilion Bay, Louisiana. Bull. Mar. Sci. 24: 52–75.

Perrett, W.S., B.B. Barrett, W.R. Latapie, J.F. Pollard, W.R. Mock, G.B. Adkins, W.J. Gaidry, and C.J. White. 1971. Cooperative Gulf of Mexico estuarine inventory and study, Louisiana. Phase 1 -Area description, Phase 4 -Biology. La. Wildl. Fish. Comm., New Orleans, 175 pp.

Reid, G.K. 1954. An ecological study of the Gulf of Mexico fishes in the vicinity of Cedar Key, Florida. Bull. Mar. Sci. 4(1): 1–94.

Reid, G.K. 1955. A summer study of the biology and ecology of East Bay, Texas, Part II. Texas J. Sci. 12(4): 430–453.

Reid, G.K., A. Inglis, and H.D. Hoese. 1956. Summer foods of some fish species. Southwestern Nat. 1(3): 100–104.

Robins, C.R., R.E. Bailey, C.E. Bond, J.E. Brooker, E.A. Lachner, R.N. Lea, and W.B. Scott. 1980. A list of common and scientific names of fishes from the United States and Canada. Amer. Fish. Soc. Spec. Publ. 12 (*4th ed.*).

Roessler, M.A. 1970. Checklist of fishes in Buttonwood Canal, Everglades National Park, Florida, and observations on the seasonal occurrence and life histories of selected species. Bull. Mar. Sci. 20: 860–893.

Rogers, B.D., and W.H. Herke. 1985. Estuarine-dependent fish and crustacean movements and weir management. Pgs. 201–219, *In:* C.F. Bryan, P.J. Zwank, and R.H. Chabreck (*eds.*), Proc. 4th Coastal Marsh and Estuary Management Symposium, Louisiana St. Univ., Baton Rouge.

Shaw, R.F., B.D. Rogers, J.H. Cowan, Jr., and W.H. Herke. 1988. Ocean-estuary coupling of ichthyoplankton and nekton in the northern Gulf of Mexico. Amer. Fish. Soc. Symp. 3: 77–89.

Sheridan, P.F. 1979. Trophic resource utilization by three species of sciaenid fishes in a northwest Florida estuary. Northeast Gulf Sci. 3(1): 1–15.

Sheridan, P.F., and D.L. Trimm. 1983. Summer foods of Texas coastal fishes relative to age and habitat. Fish Bull. 81(3): 643–647.

Sheridan, P.F., D.L. Trimm, and B.M. Baker. 1984. Reproduction and food habits of seven species of northern Gulf of Mexico fishes. Contrib. Mar. Sci., Univ. Texas 27: 175–204.

Shlossman, P.A., and M.E. Chittenden, Jr. 1981. Reproduction, movements, and population dynamics of sand seatrout, *Cynoscion arenarius*. Fish. Bull. (U.S.) 79(4): 649–669.

Simmons, E.G. 1957. An ecological survey of the upper Laguana Madre of Texas. Publ. Inst. Mar. Sci., Univ. Texas 4: 156–200.

Simmons, E.G., and H.D. Hoese. 1959. Studies on the hydrography and fish migration of Cedar Bayou, a natural tidal inlet on the central Texas coast. Publ. Inst. Mar. Sci., Univ. Texas 6: 56–80.

Springer, V., and K. Woodburn. 1960. An ecological study of the fishes of the Tampa Bay area. Florida St. Bd. Conserv. Mar. Lab., Prof. Pap. Ser. No. 1, 104 p.

Sutter, F.C., and T.D. McIlwain. 1987. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Gulf of Mexico)—sand seatrout and silver seatrout. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.72), U.S. Army Corps Engineers, TR EL-82-4. 16 p.

Swingle, H.A. 1971. Biology of Alabama estuarine areas—Cooperative Gulf of Mexico estuarine inventory. Alabama Mar. Resourc. Bull. 5: 1–123.

Swingle, H.A., and G. Bland. 1974. A study of fishes of the coastal water-courses of Alabama. Alabama Mar. Resourc. Bull. 10: 17–102.

Sykes, J.E., and J.H. Finucane. 1966. Occurrence in Tampa Bay, Florida, of immature species dominant in Gulf of Mexico commercial fisheries. Fish. Bull. (U.S.) 65(2): 369–379.

Tagatz, M., and P. Wilkens. 1973. Seasonal occurrence of young Gulf menhaden and other fishes in a northwestern Florida estuary. U.S. Dept. Commer., NOAA, NMFS Spec. Sci. Rep. 672, 14 pp.

Tarbox, K. 1974. Seasonal occurrence, distribution, and relative abundance of juvenile fishes at Marsh Island, Louisiana. Master's Thesis, Louisiana St. Univ., Baton Rouge, 121 pp.

Trent, W.L., E.J. Pullen, C.R. Mock, and D. Moore. 1969. Ecology of western gulf estuaries. Pgs. 18–24, *In:* Rep. Bur. Comm. Fish. Biol. Lab., Galveston, Texas, fiscal year 1968. U.S. Fish Wildl. Serv. Circ. 325.

Vetter, R.D. 1977. Repiratory metabolism of, and niche separation between, two co-occurring cogeneric species, *Cynoscion nebulosus* and *Cynoscion arenarius*, in a south Texas estuary. Master's Thesis, Univ. Texas, Austin.

Vetter, R.D. 1982. Seasonal metabolic compensation in sympatric seatrouts: Adaptation to the estuary. Trans. Am. Fish. Soc. 111: 193–198.

Warren, J.R. 1981. Population analysis of the juvenile groundfish on the traditional shrimping grounds in Mississippi Sound before and after the opening of the shrimp season, 1979. Master's Thesis, Univ. Southern Miss., Hattiesburg, 94 p.

Warren, J.R., and F.C. Sutter. 1982a. Industrial bottomfish-by-catch statistics, p. 1–102. *In:* Fishery Monitoring and Assessment Completion Report, 1 January 1977 to 31 December 1981, Ch. II, Sec. I, Proj. No. 2-296-R, Gulf Coast Res. Lab., Ocean Springs, Mississippi.

Warren, J.R., and F.C. Sutter. 1982b. Industrial bottomfish-monitoring and assessment, p. 43–69. *In:* Fishery Monitoring and Assessment Completion Report, 1 January 1977 to 31 December 1981, Ch. II, Sec. I, Proj. No. 2-296-R, Gulf Coast Res. Lab., Ocean Springs, Mississippi.

Warren, J.R., H.M. Perry, and D.L. Boyes. 1978. Industrial bottomfish, p. 24–118. *In:* Fishery Resource Assessment and Monitoring, Mississippi, 1 October 1973 to 30 September 1976, Proj. No. 2-215-R, Gulf Coast Res. Lab., Ocean Springs, Mississippi.

Weinstein, M.P., and R.W. Yerger. 1976. Protein taxonomy of the Gulf of Mexico and Atlantic Ocean seatrouts, genus *Cynoscion*. Fish. Bull. (U.S.) 74(3):

599-607.

Wilk, S.J. 1979. Biological and fisheries data on weakfish, *Cynoscion regalis* (Bloch and Schneider). U.S. Dept. Commer., NOAA, NMFS, N.E. Fish. Cent, Sandy Hook Lab, Tech. Ser. Rep. No. 21, 49.